

## **Background material for presentation on Steller sea lion prey**

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The mission of the Fishery Interaction Team (FIT) was to support NMFS and NPFMC analyses (such as BiOps and EIS) with regard to the ecosystem impacts of human activities such as fishing. The primary focus of FIT research was to determine whether commercial fishing operations are capable of impacting the foraging success of endangered Steller sea lions either through disturbance of prey schools or through direct competition for a common prey. FIT investigated the effects of commercial fishing on sea lion prey fields in two ways. First, by conducting field studies to directly examine the impact of fishing on sea lion prey fields and to evaluate the efficacy of trawl exclusion zones. Second, by studying fish distribution, behavior, movement and life history at spatial scales relevant to sea lion foraging (tens of nautical miles).

### Status and strategies to obtain ecosystem data

*Pacific cod localized depletion study.* The FIT project on Pacific cod was an at-sea experiment to test the hypothesis that commercial fishing causes localized depletion of sea lion prey. The project was conducted around Cape Sarichef near Unimak Pass in the S.E. Bering Sea, an area where commercial trawling for Pacific cod is highly concentrated during the winter. The 10-nm (18.5-km) trawl exclusion zone around the sea lion haulout at Cape Sarichef provided spatially adjacent treatment (trawled) and control (untrawled) areas. Full details of the methods and results can be found in (Connors and Munro 2008). Frequency distributions of the January to March percent change in cod abundance showed no statistically significant difference between trawled and untrawled areas during all three years, based on the Wilcoxon rank sum test. In other words, the difference in percent change between areas that would be expected to result from localized depletion in the trawled zone was not observed. Recoveries of fish tagged during 2003 indicate that over 70% of the fish tagged moved more than 18.5 km (the radius of the trawl exclusion zone) from the release location during a period of two weeks (Rand et al. 2014). The localized depletion hypothesis is based on the assumption of a closed pool of fish that is reduced by fishery removals. The tagging data indicate that the local population of Pacific cod in this study area was not closed and static but a shifting, dynamic mix. Fishing removals may have had an immediate effect on local cod abundance but the effect could have been obscured by fish movement at scales greater than that of the experiment.

*Atka mackerel tagging.* The FIT project on Atka mackerel was designed to examine the efficacy of trawl exclusion zones at protecting Steller sea lion prey from the localized effects of commercial fishing. The objective was to use tag release and recovery methods to estimate abundance and movement of Atka mackerel inside and outside the trawl exclusion zones at several sites in the Aleutians Islands: Seguam Pass, Amchitka Island, Tanaga Pass and Kiska Island. All these sites are adjacent to Steller sea lion rookeries or haulouts and are areas of concentrated commercial fishing for Atka mackerel. Ten- to twenty- nautical mile (18.5- to 37- km) trawl exclusion zones around sea lion sites were located in each area. Full details of methods and results can be found in (McDermott and Haist *accepted*). Mark-recapture methods were used for this study because variance estimates in tagging studies are unaffected by the patchiness typical of Atka mackerel distributions. Atka mackerel population numbers, biomass, movement rates, tagging survival rate, and tagging reporting rate were estimated using an integrated model that uses maximum likelihood to estimate all parameters simultaneously (McDermott et al. 2005). There appears to be geographic variability in the potential

efficacy of trawl exclusion zones. Trawl exclusion zones at Seguam Island, Tanaga Island and Kiska Island, where Atka mackerel biomass is relatively high and movement from inside to outside the exclusion zone is relatively low, may be effective at preserving prey for sea lions. In contrast, the trawl exclusion zone at Amchitka Island South, where biomass is relatively low and movement from inside to outside the zone is high, may be less effective. Auxiliary data collected during the tag release and recovery study indicate that Atka mackerel use the areas inside zone boundaries for both feeding and reproduction during the summer (Cooper and McDermott 2011, Rand and Lowe 2011).

*Pollock localized depletion study.* The FIT walleye pollock project was also an at-sea experiment to examine the effects of commercial fishing on fish distribution and abundance. The study was designed to detect localized depletion and changes in small-scale vertical and horizontal distribution resulting from commercial fishing. Results of the experiment are published in Walline et al. (2012).

*Process-oriented studies.* Studies of the oceanographic drivers of fish distribution (pollock and capelin) were conducted during the pollock localized depletion experiment (Hollowed et al. (2007), Logerwell et al. (2007) and Logerwell et al. (2010)). Studies of the climate and oceanographic drivers of fish reproductive biology have been carried out for Pacific cod in the Bering Sea (Neidetcher et al. 2014), pollock in the Gulf of Alaska (Ben Williams, Univ. Alaska Fairbanks, unpubl.) and Atka mackerel in the Aleutian Islands (Cooper et al. 2010, and Cooper and McDermott 2011). A study of Pacific cod movement over multiple spatial scales was published by Rand et al. (2014). Spatial variation in Atka mackerel foraging ecology and growth in the Aleutian Islands was demonstrated in papers by Rand et al. (2010 and 2011).

#### Inclusion of data into management advice

FIT research results have been cited in ESA Section 7 Biological Opinions (NMFS 2010 and 2014); and the Steller Sea Lion Protection Measures Environmental Impact Statement (NMFS 2014). FIT research results have also contributed to the Biological Report on Steller sea lion Critical Habitat (in prep; <https://alaskafisheries.noaa.gov/pr/ssl-critical-habitat>). FIT research is cited in Stock Assessment and Fishery Evaluation Reports for Atka mackerel (Lowe et al. 2015), Bering Sea Pacific cod (Thompson et al. 2015) and Gulf of Alaska Pacific cod (A'mar et al. 2015).

#### Peer review and communication

The management documents described above are all peer-reviewed. In addition, FIT staff have published in several peer-reviewed scientific journals: Fishery Bulletin (3 papers), Reviews in Fisheries Science (1 paper), Alaska Fisheries Research Bulletin (1 paper), Fisheries Oceanography (3 papers), Aquatic Mammals (1 paper), Deep-Sea Research II (2 papers), Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science (6 papers), Canadian Journal of Fisheries and Aquatic Sciences (1 paper). FIT staff have also been involved in a variety of outreach activities including presentations to fishing stakeholders in Alaska; public presentations at the Museum of the Aleutians in Dutch Harbor and the Pacific Science Center in Seattle; and activities at public schools (elementary to college) in Dutch Harbor, Anchorage and Seattle.

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